POWER PVTECH

SPECIAL REPORT

Solar in the Middle East and North Africa

Perfect storm

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Mopping up

Effective O&M strategies for desert PV power plants

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Solar hardware for desert environments

Perfect storm sets scene for solar in MENA

Market update | Falling fossil fuel subsidies, rising power demand and squeezed public coffers are bringing the most cost competitive power source to the fore in the Middle East, solar. John Parnell looks at the numerous routes to market emerging in the Middle East and the developments driving them on

Credit: Masdar

It's understandable that some in the solar industry became a little exasperated by the early days of solar power in the Middle East. There was lots of talk and huge solar targets were dangled in front of the industry. The ambition was there before the necessary regulations, resulting in what appeared to be an epic false start. Saudi Arabia announced it would invest US$109 billion into solar back in 2012. This was coupled with a 41GW deployment target by 2032.

"I understand why you might call them false starts but I would just say they were delays for a new market," says Dr Raed Bkayrat, research director at the Middle East Solar Industry Association (MESIA) pointing out that many in the region, including Saudi Arabia, are still undertaking the reforms necessary to build a sustainable solar industry.

Some countries in the Middle East are further along with that work than others. Successful tender rounds and the above-expectation performance of the earliest proof-of-concept projects have helped hasten along a string of additional tenders. The successful financing of the 200MW second phase of Dubai's solar park has shown that low-cost large-scale solar is bankable in the region.

With the main hurdles overcome, the next question is what shape will the next phase in the market's development take.

Bkayrat authored MESIA's recent 2016 Market Outlook, which puts anticipated tenders in the region from seven different countries in 2016 at 4GW. That's on top of the 2,972MW either under construction, with contracts awarded or with a PPA signed. There are numerous drivers behind this government-led procurement and it is Saudi Arabia that demonstrates these most succinctly.

According to Bkayrat, Saudi's peak load in summer is 58GW. The total installed capacity is 62GW. In winter, peak load is 27GW. Using solar to provide that peak power is eminently sensible. The use of trackers can deliver a flat peak or a delayed peak, to target the early hours of the afternoon when air-conditioning demand nudges the needle to its highest levels.

A combination of local and global phenomena have created good growth conditions for solar in the Middle East and North Africa.

Middle East solar procurement in 2016 (in MWs)	
Morocco	245
Algeria	2,000
UAE	1,150
Jordan	120
Egypt	250
Saudi Arabia	170
Kuwait	85

Source: MESIA Outlook 2016

When oil was US$100 a barrel, the further case made for solar was that it would free up oil and gas for export. So what do today's price levels do to the case for solar?

Scraping the bottom of the barrel

The price of oil has reached lows not seen for more than 10 years, dipping below the US$30 mark at one point. As the price of oil plummets, there is an assumption that this undermines the case for deploying solar power. In the eye of that particular storm, the Middle East, that logic is assumed to be even more potent.

For oil-producing nations encumbered with highly subsidised fuel at home and now with a major dent in their income, an unlikely opportunity presents itself. While the price of the raw material falls, the saving can be used to decrease the subsidy component. Reducing subsidies is not popular and creating unrest among its citizens was not an option the wake of the Arab spring.

In the last few months however, Kuwait, Saudi Arabia and the UAE have all brought the costs of fuels closer to market prices.

"Five years ago when oil was US$100 they were enjoying massive revenues and investing heavily in infrastructure; they were not too worried by the energy subsidies and they didn't pay too much attention to solar," says Bkayrat. "They started talking about solar five years ago but the motivation wasn't there because the cash was flowing in nicely. Most of the projects they were tendering were on an EPC basis and the government owned the asset, they weren't public-private partnerships or an IPP model. As cash started drying up, this brought to a halt the infrastructure projects tendered on an EPC basis and forced the government to revise

their subsidies."

Bkayrat points out that with the EPC-only option off the table, and many countries facing double-digit growth in annual peak load, they need to turn to the private sector.

"The second point, which is another blessing in disguise of the drop in oil prices, is the fact that the low [energy] prices need to be revised and are being revised. The UAE has already revised the price of gasoline last year and this year all the subsidies for oil and gas and electricity rates in the UAE – deregulates them basically.

UAE energy minister Suhail al Mazrouei told the World Economic Forum in Davos this January that subsidies on electricity would be scrapped in an effort to reduce the country's dependence on the oil price. Egypt has also taken measures to reduce subsidies but the bigger development lies back in the Gulf.

"Saudi Arabia has started the process too, five years ago it would have been unheard of and now it's happening. It's the first step in a five-year reform," Bkayrat says. The reforms will increase the cost of natural gas by 67%. "Together, all those things are positive for the solar industry and even with oil at US$30, our cost of generation from solar is on a par with the average cost of generation in GCC countries," says Bkayrat. "Another industry's misery is a blessing to solar."

One immediate impact that rising liquid fuel costs have had is in the viability of off-grid commercial projects. In Saudi Arabia, Saudi Aramco has been an early mover and First Solar recently completed a demonstration project for a major agricultural firm in the kingdom.

"Diesel [in Saudi] has doubled in price from seven to 14 US cents per litre. That has shifted the cost of generation from four cents all the way to about seven to eight cents per kWh. That alone is creating a lot of attention," says Bkayrat. "Electricity will, I expect, float at nine cents for industrial applications and solar is in the range of six to seven cents. It is already making an economic case and we are seeing a lot more movement now in the commercial and industrial space [in KSA] because of these fuel and electricity price increases."

Jordan eyes next phase for solar

Jordan deserves the plaudits for getting its IPP programme up and running and the second 200MW phase drew bids ranging from 6.13 to 13.27 US cents per kWh.

The country increased its solar capacity target for 2020 from 600MW to 1GW but law firm Eversheds' head of clean energy and sustainability, Michelle T Davies, says there could be more cause for optimism outside of the government programmes.

"The real opportunity in Jordan, because its power prices are so high, is in the merchant project space that is net metering and wheeling projects," she says.

"Jordan's regulations preclude a split between asset ownership and the offtake so developers cannot own the projects and sell the power to an off-taker. Accordingly, high energy users will have to own the asset and contract the developer basically as an EPC. The developer cannot be the asset owner. Various structures are being developed to allow something more akin to a pure merchant project whilst remaining within the broader confines of the regulation," " she says, although at the time of writing the requirement for the off-taker to own the asset remained.

Egypt finds many ways to skin a cat

While Dubai's IPP programme has grabbed the headlines of late, and Jordan deserves kudos for its work getting through two tender rounds, it is arguably Egypt that has the most potential for the solar industry in the more immediate future.

The country completed a tender for 2.3GW of solar capacity available under a feed-in tariff (2GW of large-scale and 300MW for projects under 500kW). It was hugely oversubscribed. Eversheds' Davies says progress on those developments has been positive.

"It was oversubscribed but there was concern that the currency liquidity challenges which caused issues for certain banks could have resulted in not all of the 2GW getting through but recent developments over the last few weeks seem to indicate otherwise. The first round of solar is looking good and a significant percentage of the projects have secured funding with many others in the process of doing so," she says. A host of development banks are involved and commercial banks are now looking at whether they can do the same, she adds.

While it is the largest, quantified source of solar demand in the country, the FiT programme is by no means the only one. There is also a build-own-operate (BOO) tender for 200MW of solar capacity in the West Nile region. Davies says these will be paid out in dollars, removing the currency risk that has complicated the issue the some would-be bidders.

Then there is scope for direct agreements with the government, such as the UAE's Masdar and Saudi's ACWA Power are doing through a joint venture. Merchant projects are also an option but those opportunities could be limited by the number of bankable off-takers and whatever the wholesale power price might do in the near-term.

"Finally there are the Suez Canal projects and these are the ones that many have their eye on," says Davies. "We could be looking at very, very large projects, particularly solar, to service the various developments around the Suez Canal Authority's ambitions, which are significant. Egypt is more diverse and allows for merchant off-take to happen, and it is quite possible, that as hopefully more blue chip offtakers invest in Egypt, this will be the next phase of focus."

How low can you go?

The opportunities are numerous and varied in the MENA region, encompassing feed-in tariffs, IPP, merchant and everything in between. With the help of some cheap finance, ACWA Power's Dubai project has set the bar for PV pricing in the region with its sub-6¢ solar project. So will this price have governments and off-takers around the region scrutinising the pricing of their solar power?

"Definitively," says Gus Schellekens, partner in consultancy EY's clean energy and sustainability practice in Bahrain. "In the UAE the benchmark will now be the Dubai project and only lower offers will be considered. For other countries other factors are still in place so prices will remain higher for some time but a downward trend will also be expected."

Schellekens also expects desalination and hybrid projects (already under tender in Saudi Arabia) to become more common. He also suggests that developers should consider approaching potential off-takers directly as the amenability to (slightly) smaller projects increases.

So with PV costs continuing to slide and both electricity and liquid fuel costs rising, the economics are stacking up nicely and further dramatic downward surges in the region may not be needed. Governments and industrial customers are paying attention. It may be a while before anyone announces ambitions on the scale of Saudi Arabia circa 2012, but it is projects not targets that count, and across the region, including Saudi Arabia, solar is stepping out of the shadows. ■

Making it in MENA

Strategy | The Middle East and North Africa region offers many exciting prospects for solar developers, but also presents challenges for new entrants. Ben Willis looks at what they could learn from the early movers in the region getting the first wave of projects off the ground

Credit: Masdar

The first PV projects are appearing in the Middle East and North Africa

The solar opportunities emerging in the Middle East and North Africa (MENA) region have put it squarely on the A-list of project-hungry developers. From a handful pioneer companies that took an early lead in countries such as Jordan, recent tenders have seen players from France to Japan enter the picture, drawn by the multiple government-backed programmes springing up across the region.

But the opportunities emerging in the MENA region are not without their challenges for new market entrants. While the complaints voiced by some of MENA's first movers – of opaque, labyrinthine contractual processes – have to some extent abated, the view of developers and IPPs approached by PV Tech Power is that despite the apparent pace of solar's emergence in the region, playing the long game is nonetheless an approach that pays dividends in this part of the world.

"The process of developing projects can be very lengthy – definitely lengthier than what we're used to in our home markets," says Adel Baba-Aissa, director of Renewable Energy Partner, a UK-based project developer currently working on the first independent power producer solar project in Algeria. "The main thing really is patience; you've got to realise this is a different market, so whatever you factor in for your home market, you've got to scrap that, throw it out of the window and rethink it completely."

Of course, much of that work is just part and parcel of the process that must inevitably play out as the officials and key personnel in countries coming to solar for the first time become familiar with its specific commercial intricacies. Here again the consensus is that patience is the watchword, and indeed it would seem to be in the interests of prospective developers to help move that process along by taking the lead in educating other parties on how project contracts should be put together.

Raymond Carlsen is CEO of Norway's Scatec Solar, which is currently building three projects in Jordan under the kingdom's first-round tender and currently moving forward with projects under Egypt's 2GW solar feed-in tariff. The company was also one of the early movers in South Africa, whose IPP procurement programme is regularly held up as the gold standard for such initiatives.

In all of these markets, Carlsen says, early negotiations have been protracted but necessary in order to produce satisfactory contracts. "There are a few challenges; we have seen this elsewhere: when a programme starts you need to adjust the regulatory regime to match the contractual requirements of an IPP. And doing that for the first time takes a bit of time," he explains.

Such requirements cover everything from land lease arrangements to payment terms for power purchase agreements. Carlsen says that on all of these, it is up to individual developers to help authorities understand their particular requirements and ensure watertight contracts. He cites the case of Egypt.

"We have been interfacing with the authorities for a long time providing information on how these programmes have been implemented in other countries," Carlsen says. "In Egypt's case, they have been able to absorb that and understand how this would impact the regulatory regime in their own country and where you need to make certain adjustments to make these projects bankable and make them fly."

Currency and tenders

One particular issue that has not yet been resolved, and which appears to be a source of some concern at the moment, is the question of foreign currency risk in the MENA region.

"Most MENA countries are linked to how well or badly the oil and gas markets are doing," explains Baba-Aissa. "This has seen a lot of volatility in the currencies, which means there are issues around liquidity as some of the PPAs are payable either partially or totally on foreign currency – i.e. US dollars. And since revenues in most of these countries are highly dependent on the sale of oil and gas, there is some risk that there may be a liquidity risk there."

Baba-Aissa stresses that the risk from this is not immediate, but is something developers should be aware of looking

further ahead. "A lot of the oil and gas-rich countries are still sitting on massive reserves of dollars, so it's not something you need to worry about for probably the next 12-18 months, but if prices continue, it's definitely something to bear in mind," he says.

It's an issue that is certainly on the radar for Rafael Benjumea, CEO of Fotowatio Renewable Ventures, a Spanish firm that was recently acquired by the Saudi Arabian conglomerate, Abdul Latif Jameel. The company is involved in Jordan's 200MW second-round solar tender as well as working on projects in Dubai and Egypt, and in Egypt Benjumea says the currency question is a particular issue. "We are looking at it very deeply to understand how can we solve it and how can we get comfort with that as a long-term investment," he says.

Another matter that has emerged in some of the other programmes in which FRV is participating is that of the level of evidence required of financial backing at the bidding stage. In the case of the Dubai tenders, for example, bidders have been asked to have financial close on projects or committed finance from banks, something that Jordan, for example, does not ask for at that stage. Demanding such levels of finance-readiness is not always helpful in realising the best possible price for a project, Benjumea says.

"My preference is to be less committed when I am bidding," he says. "I am happy to give a letter of credit to support my bid and I am happy to commit my reputation, but I have learned that if I win a project my ability to negotiate with providers and banks is much bigger than if I am in the bidding process. Those kind of tenders, where they request everything is fully closed, are introducing some inflexibility that will have some impact on prices."

Such requirements are no doubt intended by authorities to act as safeguards against overzealous bidders getting carried away in the increasingly cutthroat tenders taking place in the MENA region. These have become a central feature of the MENA markets in the past couple of years and yielded some memorable headlines, the most notable being the sub-US$0.06 per kilowatt-hour winning bid from IPP ACWA Power for the 200MW second phase of Dubai's Mohammed bin Rashid Al Maktoum Solar Park, eventually expected to top 5GW.

While for solar in general the increasingly competitive pricing seen in some of the MENA tenders is a positive story the flip-side to that is that it makes market entry harder for smaller developers. According to Baba-Aissa, non-tender procurement processes are increasingly rare in the region, other than in Algeria where his company is active.

"We're definitely watching this trend very carefully," he says. "We're seeing a lot of countries outside of the MENA region, even in sub-Saharan Africa, going this way. There are still enough markets out there that are not tender-based that it's ok for now. But if more and more countries go down this route, it is going to exclude quite a big section of the market. This is a worrying trend the way we see it."

Nevertheless, for Benjumea the tender process in the Middle East has been an "efficient" way of quickly stimulating market activity, particularly in Egypt, where the demand for power is immediate and pressing. "You only have to see the result of the prices," he says.

Carlsen also highlights how the increasingly low pricing being achieved in some of the Middle East tenders signifies crucial advances in the way the solar industry is securing finance.

"People tend to look at the price per kilowatt hour without understanding what brings you to whatever level that is at," he says. "The ACWA project was pretty competitive. But if you dive below the clouds there and look at how they can do that, well it was because they had financing that had never been seen before."

That's a key point, as aside from the cost of equipment, the cost of capital is the other key determinant of a project's overall price. Carlsen believes that the prices being achieved in the Dubai tender indicate how much progress solar is making from an investor perspective: "We've seen the same in South Africa, we've seen the same elsewhere: financing is becoming more and more competitive, which is good for the industry as a whole."

And it seems likely that ACWA's bid in Dubai won't be the lowest we'll see. In maturity terms, the MENA solar markets are really only in their first stages of development. As they develop, one near-certainty is that whereas until now much of the expertise and money that has been coming into the region's emerging solar markets has been coming from overseas, more and more of that is going to be coming from local sources.

"There's so much money around in the Middle East I'd be surprised local investors aren't going to get in on the act," says Baba-Aissa. "It's natural that for the first tranche of projects for the first few years of when a market evolves from nothing that only the most sophisticated people in the market will take a look at that. But there is going to be this copycat effect as people get more comfortable with technology risk, get more comfortable with the markets and understand that governments really are behind this."

As things stand, the prospects for solar in the MENA region have never looked better. Government programmes appear to be having the desired effect in kick-starting market activity, opening up new prospects and making solar an increasingly competitive energy source for the region.

Seemingly the biggest barrier for would-be developers or IPPs wanting to access MENA's many opportunities at the moment is simply one of competition. But prospectors should not forget that the region's biggest solar-market-in-waiting, Saudi Arabia, has not yet even begun to get going. If the Saudi giant stirs and anything like the +40GW solar programme previously under discussion is put on the table, there will be plenty more opportunities there for the smart developer to take. ■

Solar programme highlights in the MENA region

United Arab Emirates:
- Dubai: Aiming to meet 25% of its power needs from solar by 2030, by which point rooftop PV will be mandatory; 5GW of utility PV planned under multi-phased Mohammed Bin Rashid Al Maktoum Solar Park
- Abu Dhabi: Tender for 350MW of solar planned in 2016

Egypt:
- Targeting 2.3GW of solar by 2017 – 2GW of centralised utility projects, 300MW decentralised

Jordan:
- Contracts for 200MW of PV awarded in round-two tender in 2015; a cancelled round-three tender of 400MW is not expected to restart until grid issues are resolved

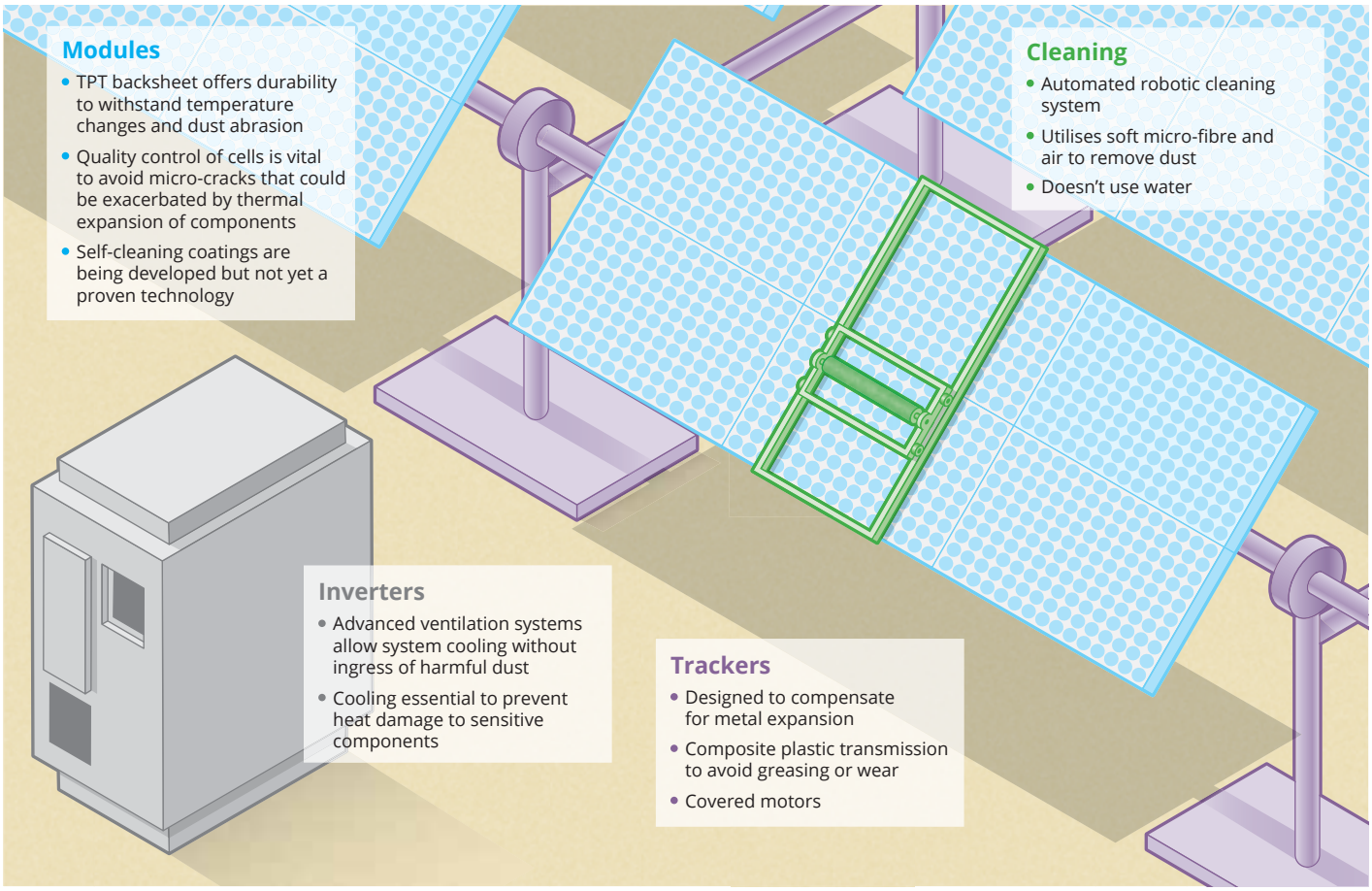
Algeria:
- Around 268MW of PV projects completed in 2015; the country is targeting 13GW by 2030, with a feed-in tariff and draft PPA now in place
- One of the few MENA markets not following the tender route

Morocco:
- 20 IPP consortia have pre-qualified for the 170MW NOOR PV I project, with three separate projects expected to make up this capacity. Final winners expected to be chosen in early 2016
- Three projects totalling 75MW are being contracted under a separate 400MW programme by Moroccan utility ONEE, though on an EPC basis only

Source: Middle East Solar Industry Association

Desert-proof

Hardware | Much work has gone into adapting PV equipment to withstand the rigours of the desert, which range from dust to wide temperature fluctuations. John Parnell and Ben Willis look at how some the main elements of a PV power plant are being made desert-ready



Infographic: Leonard Dickinson

Key attributes of PV system components in desert conditions.

MODULES

Aside from the obvious impacts of dust and sand, PV modules deployed in the desert must be able to contend with large temperature fluctuations.

"In the desert the temperature can go up during the day to over 50C and in the night it can go below zero," says Nabih Cherradi, chief technology officer for Desert Technologies, a Saudi-based developer and module manufacturer. "So you can have a lot of problems just generated by the temperature regardless of sandstorms."

The potential problems caused by such a wide temperature gradient arise from the differing thermal expansion coefficients of the various module components – the glass, cell, ribbon and backsheet. These can inflict damage on cells or exacerbate any existing flaws in cells such as micro-cracks. For this reason, keeping tight control of the quality of cells going into modules to be used in desert areas is of paramount importance, says Cherradi.

Another factor for desert modules is the quality of material used for backsheets. High temperature again is a factor here, but so too are the effects of erosion from sand and dust. Cherradi's view is that only TPT backsheets, which sandwich polyethylene terephthalate (PET) between two layers of polyvinyl fluoride film (often known by its brand name, Tedlar), offer the kind of durability needed to withstand the temperature and abrasive forces found in the desert.

Then there is the issue of dust settling on module surfaces. A number of cleaning solutions have been developed for desert modules (see p.40). Research is also ongoing to develop 'self-cleaning' modules coated with special materials designed to prevent dust settling, but these are not yet proven technologies. Furthermore, says Cherradi, they don't address the issue of humidity, something that can be a big problem in the desert and causes dust to stick, Cherradi claims.

A number of companies produce modules said to withstand desert conditions, but Cherradi is sceptical about some of the claims being made. His main contention is over whether the necessary controls are in place to ensure the quality of the cells in the context of the issue around thermal expansion of components. "I would advise the people who don't have deep technical knowledge, the EPC people, to hire consultants to really check," he says.

Various other research efforts are also going on around the world to develop desert-specific modules. Notable among these is the 'AtaMo' project, which is creating a module designed for the conditions found in Chile's Atacama Desert (see p.55, *PV Tech Power*, Issue 5). As these are perhaps even more extreme than those found in the MENA region, researchers on this project have suggested adaptations of the AtaMo module could be made for the Middle East and other arid parts of the world.

INVERTERS

With more potential for failure during operation than modules, getting the right inverters for your project is crucial. As with other components, heat and dust are the two main enemies for inverters in desert conditions.

Most of the major inverter suppliers have developed technologies specifically designed to allow inverters to function in the desert.

German inverter specialist SMA Solar has developed its own OptiCool system, which, as the name suggests is designed to keep the inverter running in the oppressive heat of the desert. To do this without exposing sensitive power electronics to fine dust and sand, two ventilation circuits run in tandem – one for the less sensitive components using the outside air, and a second internal circuit for the rest, explains Khalid Al-Dam, programme manager at SMA Solar.

"We developed a type of sealing between the two cycles that stops the dust from passing from the outside to the inside ventilation cycle," says Al-Dam.

The sealing between the two cycles becomes vital in order to maintain the separation of the two cycles. "We have to control the airflow," explains Al-Dam. "SMA is a power electronics company though and designing sealing is not our main competence. So what we have done is look at the different sealing techniques and materials in the market and work with a number of partners to find how best to do this."

In order to prove the desert-readiness of its Sunny Central inverters SMA used crushed roof tiles in its lab testing to simulate the finest dust.

"We used this test procedure, based on a lot of projects in the US desert with the same temperatures and extreme climatic condition as the Gulf – temperatures of up to 50C and sandstorms impacting the equipment," says Al-Dam. "So the simulation takes into account the size of the sand and dust and the duration and direction that the sandstorms come from to make sure that we simulate the same conditions as in the desert as accurately as possible."

The inverters are designed to be used outside, walled off but with no roof covering and Al-Dam admits that one customer in the US took some convincing.

"We ran a nine-month test in Arizona, in the Sonora Desert, for two different outdoor systems. There were sandstorms and the test covered the entire summer period. We went back with the customer after nine months to open the unit to see how much dust was in to determine how often the system might need attention and they were surprised that there was almost nothing. So we have come to the conclusion that yes, we can install the unit outside and we can increase the amount of time between maintenance." Ultimately, Al-Dam says, the customer made a "huge order".

Ongoing support was also provided by placing a resident engineer in the O&M department of the customer to learn what they needed at that particular site.

"We appointed a resident engineer with the customer, in the O&M department, who worked together with them. They visited the different PV parks to see what the client needed. Working very closely with them customer gave us a lot of experience, and helped build their trust in the products."

TRACKERS

Trackers are an increasingly ubiquitous part of the modern utility-scale power plant, particularly in areas of high irradiation. With that in mind it is reasonable to assume we'll see plenty more trackers used in projects across the Middle East. With summer peak loads creating headaches, the production profile of a solar plant with tracking offers huge benefits by displacing the use of peaker plants and creating a flat peak over several hours.

But with dreaded 'moving parts' to contend with, how can tracker technology withstand the rigours of the region? Jean-Noel de Charentenay, VP of strategy and co-founder of tracker specialist Exosun explains the company's approach.

"The critical point is the piece that spreads the movement to the table. Our transmission is based on a composite plastic to avoid [the need for] any greasing or wear. That's why we don't need to seal this mechanism," he says.

The fact that trackers are used in areas with high irradiation, which in the absence of altitude tend to be very hot climates, means they are often designed from the outset to cope with harsh conditions, explains De Charentenay. "Everything is also designed from the outset to cope with the expansion of the metal that might occur as the temperature increases," he says.

"We use a protective cover on the motors to ensure they are never hotter than the ambient temperature and they can function up to 50-60C which is the highest temperature you will get in these regions," says De Chartentenay, "and because we use less motors per megawatt, we use higher quality motors that are completely sealed for their lifetime".

Generally, the move in the tracker business has been towards systems that are sealed and require little or no maintenance, an approach that is beneficial anywhere, but particularly in harsh, potentially remote desert sites.

"Simple is better and we try to do that in an elegant way," says Ron Corrio CEO of US tracker supplier, Array Technologies.

"We have eliminated any maintenance from the system; our v2 system had to be greased but now the gearing is in a sealed housing, sealed and lubed for life. Everything is made to survive 30 years without maintenance."

CLEANING

As dust settling on modules can drastically reduce their power, cleaning is a vital part of the operation of a PV power plant in the desert.

Various technologies are appearing on the market to automate this process. However, the jury is still out on which of these offer the best solution to keeping modules operating at an optimal power over their 20-25-year lifetime.

Recent research has suggested that some cleaning systems on the market used with certain types of module can cause damage to module surfaces, leading to a permanent loss of power. Another obvious consideration for cleaning systems in desert environments is that they must minimise or eliminate altogether the need for water use in the cleaning process.

"You have to be sensitive to the environment that these plants are going to operate in," says Scatec Solar CEO Raymond Carlesn. "And of course access to water, soiling on the panels, cleaning frequencies and things like that are going to be very key."

One company that claims to have come up with the answer to the module soiling issue is the Israel-based firm Ecoppia. Ecoppia's robotic cleaning system uses a combination of a soft micro-fibre and air to remove dust, without the need for water or abrasive brushes.

"You want something gentle that does no damage to the PV cells, that puts as little as possible load on the array tables and that can clean for as low a cost as possible, as frequently as possible and with as little need for water as possible. Those are the driving statements we used to build our solution," says company spokesman, Adam Taylor.

Tests of Ecoppia's robot with German lab PI Berlin showed encouraging results. "We did a simulated test for over 20 years, and in that test it was shown we did absolutely zero damage to the PV panels and kept them producing at peak capacity," Taylor claims.

The Ecoppia robot has also been designed to minimise damage to modules through loading. "If you see our robots in action, they're just lightly brushing the panels as they go past, so there's no load on the panels," Taylor adds.

So far, Ecoppia claims to be the leader in what is a relatively new sub-market for the solar industry, with 270MW of its robots set to be installed globally by the end of 2016. But with more and more solar being built in the desert that looks set to change. "There are companies that are keen to get into this space, I think you're going to see a lot of different designs tried," Taylor says.

Mopping up in the desert extremes of the Middle East

Credit: PI Berlin

O&M | The MENA region's conditions present some unique problems for PV power plant operators. As Tom Kenning discovers, getting the right O&M regimes in place is just as important as the technology

Temperatures oscillating from one extreme to another, high winds and copious amounts of sand and dust make the vast desert regions of the Middle East a unique challenge for operating and maintaining a solar plant. Despite recently emerging as a multi-gigawatt market, with more than 4GW of solar power to be procured in the region during 2016, according to recent analysis by the Middle East Solar Industry Association (MESIA), experience of operating a plant in these distinctive conditions is still fairly limited. Lack of access to water has been the main driver for new technologies in this O&M sector with various dry-cleaning and automated cleaning solutions becoming widespread, but there are disputes in the industry over whether these systems can cause more harm than good and what the most efficient method is for keeping PV power plants operating profitability over their planned lifetime.

There are several key causes of concern for a plant operator in desert regions, starting with whether the high temperatures can affect module efficiency. Secondly, while winds can alleviate problems of heat, they can also bring with them sand and dust, which blocks the PV modules. Thirdly, while the extremely limited rainfall in the region can help to clean modules in certain scenarios, high levels of humidity also serve to increase the adhesion of sand and dust on top of the module surfaces. All these factors mean that the seasons have a large say in the frequency of cleaning regimes and how necessary testing and modelling will be.

When it comes to cleaning modules, there are a variety of solutions available on the market, ranging from robots that clean the modules using water, to dry-cleaning systems that use air pressure or brushes.

Klaus Friedl, managing director of global solar developer Phoenix Solar Overseas, explains how Phoenix tested a solar array with oil company Saudi Aramco starting in 2010 for a period of three years and also signed an agreement to perform O&M services on a Turkish plant, to gain an understanding of best practices.

Phoenix purchased a cleaning machine for the Turkey project, which can be taken over the entire module row by hand or behind a unimog, which is an auto four-wheel drive truck, however relatively frequent rain means cleaning is required less regularly than in some desert conditions.

The company tends to stick to a rota of three dry cleans followed by one clean with water, both using brushes. This whole cycle can take place within three weeks or up to just two times per year depending on conditions.

Dust is just one of the O&M challenges in the desert

For a PV plant near to Dhahran, a city located in Saudi Arabia's Eastern Province, Friedl says that cleaning is required every three weeks, partly because it only rains two to three times per year. In the summer, humidity means that sand sticks to the modules. If no cleaning is performed in two months, the plant modules see an efficiency reduction of between 26-32% on average. By cleaning every three weeks there are output losses of just 2-5%.

However, cleaning is less frequent in December to February, when the weather is less hot and dusty, the air is cleaner and less humid, and there do not tend to be sandstorms.

"Dry cleaning is also possible in very dirty environments, if you clean every two to three weeks," says Friedl. "If you leave the dust longer on the modules, then it really sticks to the module surface and you cannot clean it dry anymore. Then you have to clean it with water."

The firm also uses software to calculate when the systems are performing at 2-5% less efficiency, which indicates that they needs cleaning. This is important as plant

operators may have to pay a penalty to the client if the plant is performing below its estimated output.

On the occasion of a dry sandstorm, cleaning with brushes can become obsolete and cleaning manually is often necessary. The modules being at a 20 degree inclination on average also means that cleaning needs to be done more thoroughly than with panels at a higher inclination.

"It's labour intensive but we need the labour only for a day or two depending on the site," adds Friedl.

There are some odd variances geographically. For example, while the Dhadhran plant is located near to the Gulf Coast, opposite Bahrain, where one would expect the benefits of less humidity and more wind coming from the sea, it still requires far more cleans than another Phoenix plant situated in central Saudi Arabia by the capital of Riyadh. The 5.2MW Riyadh plant did not require a single clean in 2013, and it managed to over perform by 6%. The following year, it required just two cleans. The wind climate is fairly similar in both Riyadh and Dhahdran, so in this case it was the humidity that made all the difference in the varying O&M requirements, says Friedl.

Besides dry and water-based cleaning methods, there are various chemical solutions available, however, Friedl says that they have not been working as well as expected. As a result Phoenix has continued with brushing methods, which always require approval from the module manufacturer first so that the guarantee or warranty is not lost should damage occur.

Trial and error

Sami Khoreibi, chief executive and founding partner of Middle East and North Africa based solar developer Enviromena, says that humidity and moisture levels dictate what time of day modules are cleaned on Environmena plants, however it is generally a regular schedule. For example, unexpected morning dew can mean delaying a clean to make sure the modules are dry before beginning.

"When it comes to O&M it is actually quite simple," says Khoreibi: "Keep the panels clean and ensure that they are cared for after something like a sandstorm, which is a relatively rare occurrence."

Khoreibi also insists that the net overall positive impacts of strong irradiation in the Middle East outweigh the negatives felt from the dust or challenging O&M conditions, especially when compared to having a solar plant in less dusty but cloudier climates.

Khoreibi says his firm learned many lessons by starting with a 10MW solar plant incorporated into Masdar City in Abu Dhabi, which was used as a test lab for methodologies on cleaning plants. The Masdar settlement has a strong emphasis on sustainability and minimising environmental impact so the team had to identify ways of keeping the plant clean with minimum water usage.

"We are using a dry brush method, but there are of course thousands of different forms of dry brushes that one can use to clean a system", says Khoreibi, "so we actually ended up trying 200 different brush head technologies."

Environmena attached wheels on either side of the chosen brushes, which then roll along the panel racks. It also worked alongside panel manufacturers Suntech and First Solar to make sure the modules were not being harmed by any micro-abrasion. As a result of the brushing, the plant's output has been able to overachieve in terms of its performance guarantees every year since beginning operation.

Environmena has considered automated technologies, but has not justified using them from a cost and technology perspective. Khoreibi says that performance issues caused by dust could become an even larger issue by using automated robots, so the company has stuck with manual cleaning so far.

German testing house PI Berlin last year developed a number of stress tests to assess the impact of cleaning systems in these desert locations and found that in some cases the cleaning methods can damage modules.

However, Juliane Berghold, head of module technology and research at PI Berlin, says that in most cases there is no visible or direct mechanical impact from cleaning technologies. The module glass can be scratched, but it is very rare to find a cracked cell.

"What is much more often the case is that the cleaning is resulting in a part removal of the functional layers like the anti-reflective coating," says Berghold, "and this has an impact because it reduces the efficiency of the module."

Nevertheless, removing these functional layers has a maximum impact of 3% on module efficiency, so output is not drastically affected. Furthermore, the chances of damage also rely heavily on the quality and mechanical stability of the modules themselves, the type of cleaning technology and the frequency of cleaning, says Berghold.

Credit: Phoenix Solar

Phoenix Solar's Kapsarc project revealed the imoprtance of humidity in the choice of module cleaning regimes.

Ultimately Friedl says that any negative impacts of poor cleaning technology is far less than the definite power output losses of leaving dust and sand on the modules. There is no alternative but to clean.

Heating up

When it comes to the effects of high temperatures, Khorebi says module degradation does increase in extreme heat, however this is well modelled and accounted for when forecasting the output of a plant. "Panel manufacturers have pretty set degradation formulas depending on additional heat per degrees Celsius," he says.

Furthermore, Khoreibi insists that higher yields coming in a climate of high heat and sunshine on a daily basis means the systems generally outperform plants from other parts of the world despite any higher rates of degradation.

Many O&M methods in the Middle East, such as monitoring plant performance, apply to other parts of the world, however plants in the desert may require testing for damage more regularly due to the temperatures, says Berghold.

The heat also means that O&M workers need to check cables and cable connections closely, says Friedl. For example, cable connectors and binders made of insufficiently protective material may have to be replaced after just one year due to exposure to the heat.

Most commentators say the difference in emerging technologies in the Middle East's O&M sector often comes down to the cleaning brushes being used, but the fact that cleaning technology is available without requiring water is a major boon for the sector. However, for some companies it will take improved technology and a stronger economic case to start adopting any automated solutions. ■